PRODUCT DEFINITION AND USERS' GUIDE

(PUG)

Volume 1: MAIN

FOR

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R SERIES (GOES-R) CORE GROUND SEGMENT

January 24, 2014

REVISION C

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Satellite and Information Service (NESDIS)
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(PUG)

Volume 1: MAIN

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Date

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PRODUCT DEFINITION AND USERS' GUIDE (PUG)

VOLUME 1: MAIN

FOR

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE

R SERIES (GOES-R) CORE GROUND SEGMENT

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VOLUME 1: MAIN

FOR
GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R SERIES (GOES-R) CORE GROUND SEGMENT

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RECORD OF CHANGE

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-	08 February 2011	Initial Release Pre-ECP5
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A	06 February 2012	Pre-CDR Release PTR 3226 Update per BCN_046 ATP for BCR 049 Metadata Delivery PTR-3525 Incorporate GSP Comments (from Interim Release) PTR-3525 Incorporate GSP Comments (CDR Release) PTR-3526 Update Content for TBDs/Action Items (CDR Release)
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		PTR-4204 SE-16 PUG Feedback on PUG for L1b Volume 3 PTR-4845 SE-16 PUG Incorporate Peer Review Comments Deferred from Rev A (Note: Updated NcML files are from 6/12 for CMI and 6/11 for all others)
B.1	17 December 2012	Post-CDR Interim Release PTR-4841 SE-16 PUG - Deferred Comments from Release A PTR-4946 SE-16 PUG - Deferred Comments from PostCDR+90 Peer Review PTR-5318 SE-16 PUG: BCN_067 ATP for ECP007 RFP Amend 4 PTR-5373 SE-16 PUG - Update PUG Vol 5 Product Algorithm Output Tables PTR-5403 Incorporate customer comments against Rev. B
B.2	20 May 2013	Post-CDR Interim Release PTR-6419 SE-16_Product Definition and Users' Guide (PUG) Release Update Rev B.2 Update due to BCR75 PTR-6158 UMB_Delivery_SE-16_Product Definition and Users' Guide (PUG) Release Update Rev B.2 PTR-6159 SE-16 PUG - Deferred Comments from Rev. B.1 Peer Review PTR-6837 SE-16 PUG Incorporate Customer Comments Against Rev B.1 PTR-6877 SE-16 Product Definition and Users' Guide (PUG) - BCN_085 ATP for MAG SEISS L1b Changes
C	6 December 2013	Post-CDR Interim Release PTR-9218 Delivery_SE-16_Product Definition and Users' Guide (PUG) Release Update Rev C 1) ITAR content and markings removed from this, and the PUG L0 and L1b volumes. 2) Other than the system and instrument overviews, and the point of contact table, this volume has been completely revised with new and updated content. 3) The subsequent version is identified where new content will be inserted into paragraphs that currently have headings and no content.

REVISION	DATE	DESCRIPTION
		PTR-7556 SE-16 PUG - Deferred GSP Comments from Rev. B.2 Review A subset of the deferred comments addressed related to the filename conventions, and several miscellaneous topics. PTR-9027 SE-16 PUG - Evaluate Customer Comments Against Rev B.2 A subset of the deferred comments addressed related to the filename conventions, and several miscellaneous topics.

ITEMS TO BE RESOLVED

The following TBx terminology is used in this and the other PUG volumes:

1. TBD: the item is To Be Determined. There is missing information where the TBD is placed. The missing information is unknown at this time.
2. TBR: the item is To Be Resolved or To Be Reviewed. The item is subject to review for appropriateness and/or subject to revision. The TBR immediately follows the item To Be Resolved or Reviewed.
3. TBS: the item is To Be Supplied. There is missing information where the TBS is placed.

Action Item	Title	Action Required
3738	TBD-7: Non-Product Data	Non-Product Data is in the process of being developed. Information in this section will be updated as it becomes available and will be modified to reflect the most recent design decisions and up-to-date information to include Instrument Calibration Data, L2+ Processing Parameters.
5343	TBD-8/TBR-8: L1b Information	Update identified L1b items as it becomes available and will be modified to reflect the most recent design decisions and up-to-date information including Input Parameters/L1b Calibration Input. Ensure inclusion of ground processing needed to obtain L1b and L0 (uncompression, calibration, navigation and resampling to fixed grid) once available.
5344	TBD-10: L0 Data Field Packet Sizes	Update identified L0 data field packet sizes as it becomes available and will be modified to reflect the most recent design decisions and up-to-date information.
5345	TBD-15: APID Data Formats	Once CDRL-43 stabilizes, update the Data Field tables for L0 to include the data formats of each APID.
5717	TBD-16/TBR-16: Data Field Tables	Update Data Field Tables for L0 and L1b products in accordance with incremental PUG refinement plan.

TABLE OF CONTENTS FOR VOLUME 1: MAIN

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Scope

The Product Definition and Users' Guide (PUG) document provides a product description and format users' guide for all data and products produced and made available to users by the Geostationary Operational Environmental Satellite R Series (GOES-R) Core Ground Segment (GS), developed under contract DG133E-09-CN-0094. This includes the Level 0 products, Level 1b products, GOES-R Rebroadcast (GRB), and Level 2+ products. This also includes ISO series metadata, instrument calibration data, and processing parameters and algorithm packages.

The PUG is divided into five volumes. This volume, Volume 1: Main contains reference material, product and data overview information and cross-reference tables to specific product and data paragraphs in the other volumes. The remaining volumes are divided by product in the following manner: Volume 2: L0, Volume 3: L1b, Volume 4: GRB, and Volumes 5A and 5B: L2+. In addition, there is a separate standalone Appendix X containing detailed descriptions of ISO series metadata for GOES-R products and data made available to users.

1.2 System Overview

The National Oceanic and Atmospheric Administration (NOAA) operates a system of Geostationary Operational Environmental Satellites (GOES) to provide continuous weather imagery and monitoring of meteorological and space environment data to protect life and property across the United States. Two GOES satellites remain operational (75 degrees west and 135 degrees west longitude) at all times providing coverage for the eastern United States and most of the Atlantic Ocean and the western United States and Pacific Ocean basin. Post-Launch Test (PLT) of new satellites is performed at 89.5 degrees west longitude. After PLT, an on-orbit spare satellite is maintained at 105 degrees west longitude (or the PLT location) to permit rapid recovery from a failure of either of the operational satellites. GOES satellites provide critical atmospheric, oceanic, climatic and space weather products supporting weather forecasting and warnings, climatologic analysis and prediction, ecosystems management, and safe and efficient public and private transportation.

The next generation GOES (designated the GOES-R Series) provides continuity of the GOES mission (at 75 degrees west and 137 degrees west longitude) and improvement of its remotely-sensed environmental data. The GOES-R system consists of the Space and Ground Segments. The Space Segment comprises the spacecraft bus, and its remote-sensing instruments and communications payloads. The Ground Segment, comprising all Earth-based functions, provides satellite operations and instrument product generation and distribution.

The primary GOES-R instrument is the Advanced Baseline Imager (ABI) that provides Full Disk, CONtinental United States (CONUS), and Mesoscale imagery for global and CONUS forecasting and severe weather warning. Secondary instruments include the Extreme Ultraviolet and X-ray Irradiance Sensor (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS), Magnetometer (MAG), and Geostationary Lightning Mapper (GLM). Additionally, GOES-R provides a set of communications services (Unique Payload Services) in support of the Data Collection System (DCS), High-Rate Information Transmission/Emergency Managers Weather Information Network (HRIT/EMWIN), and Search-and-Rescue Satellite Aided Tracking (SARSAT).

The GOES-R GS operates from three sites. The NOAA Satellite Operations Facility (NSOF) in Suitland, MD houses the primary Mission Management (MM), and selected Enterprise Management (EM), Product Generation (PG), and Product Distribution (PD) functions. The Wallops Command and Data Acquisition Station (WCDAS), located in Wallops, VA, provides the primary space communications services, EM and MM functions, and selected PG and PD functions. The third site is a geographically diverse Remote

Backup Facility (RBU), located at Fairmont, WV. It functions as a completely independent backup for the MM and selected PG and PD functions for the production of Key Performance Parameters (KPPs) and GOES Rebroadcast (GRB) data, and is capable of concurrent and remote operations from the NSOF and the WCDAS. The RBU has visibility to all operational and on-orbit spare satellites. The KPPs consist of the L2+ Cloud and Moisture Imagery (CONUS, Full Disk, and Mesoscale) product and its sectorized products. Reference Figure 1.2-1 for the GOES-R System and Ground Segment Overview.

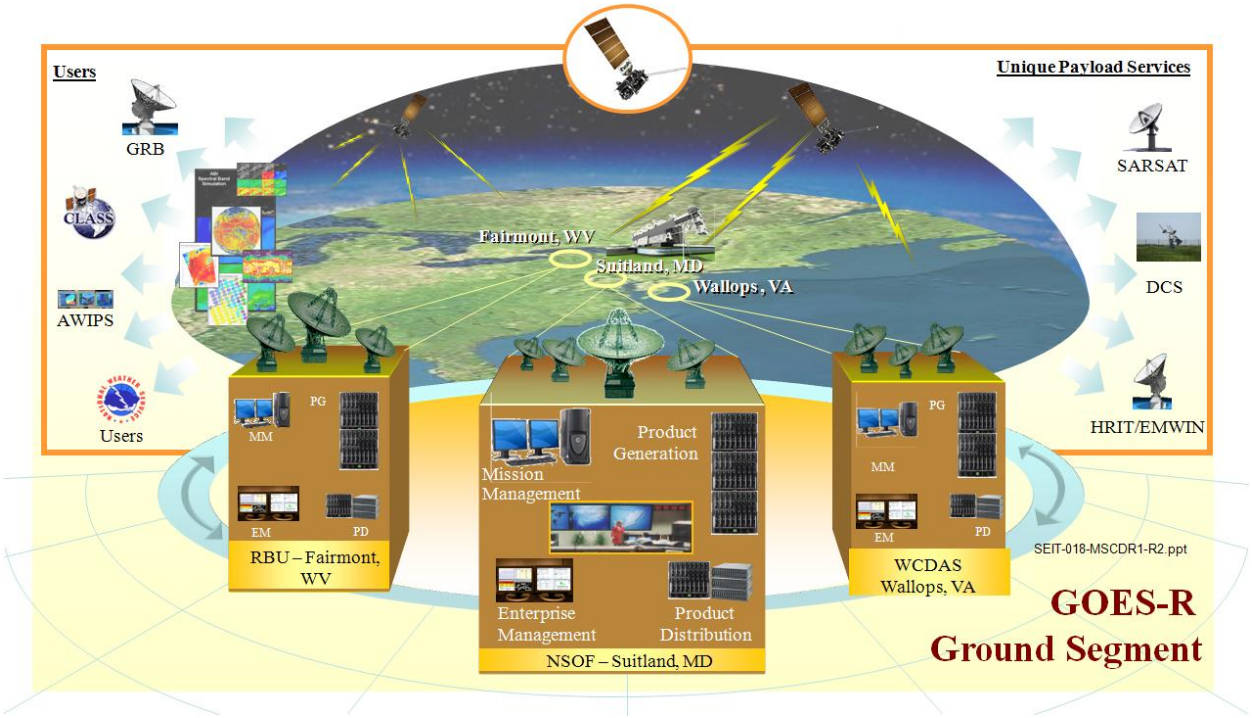

Figure 1.2-1 GOES-R System and Ground Segment Overview

The satellites are commanded throughout their mission lifetime from the NOAA Satellite Operational Control Center (SOCC) located at NSOF with the ground station radio frequency (RF) interface located at the WCDAS, or RBU. The engineering telemetry streams are received by WCDAS, and RBU, and ground relayed to the SOCC for processing and monitoring at all locations.

The raw sensor data are received by WCDAS, processed by the PG function at WCDAS to create L1b and L2+ GLM products. These L1b and L2+ GLM products are then rebroadcasted through the spacecraft GRB transponder. The GRB data are then received at NSOF where the rest of the L2+ products are created. Ancillary data used in generating the L2+ products are ingested from the Ancillary Data Relay System (ADRS). Applicable products are directly distributed to 1) the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS) where key NWS Weather Forecast Offices (WFO) and other AWIPS users get their data, 2) the Product Distribution and Access (PDA) component of the Environmental Satellite Processing and Distribution System (ESPDS), which includes the GOES-R Access Subsystem (GAS) functionality, provides data to National Environmental Satellite, Data, and Information Service (NESDIS), NWS, and other GOES data users, and 3) the Comprehensive Large Array-data Stewardship System (CLASS) for long term archive and access supporting retrospective users of GOES data. Figure 1.2-2 shows the primary data flow through the system.

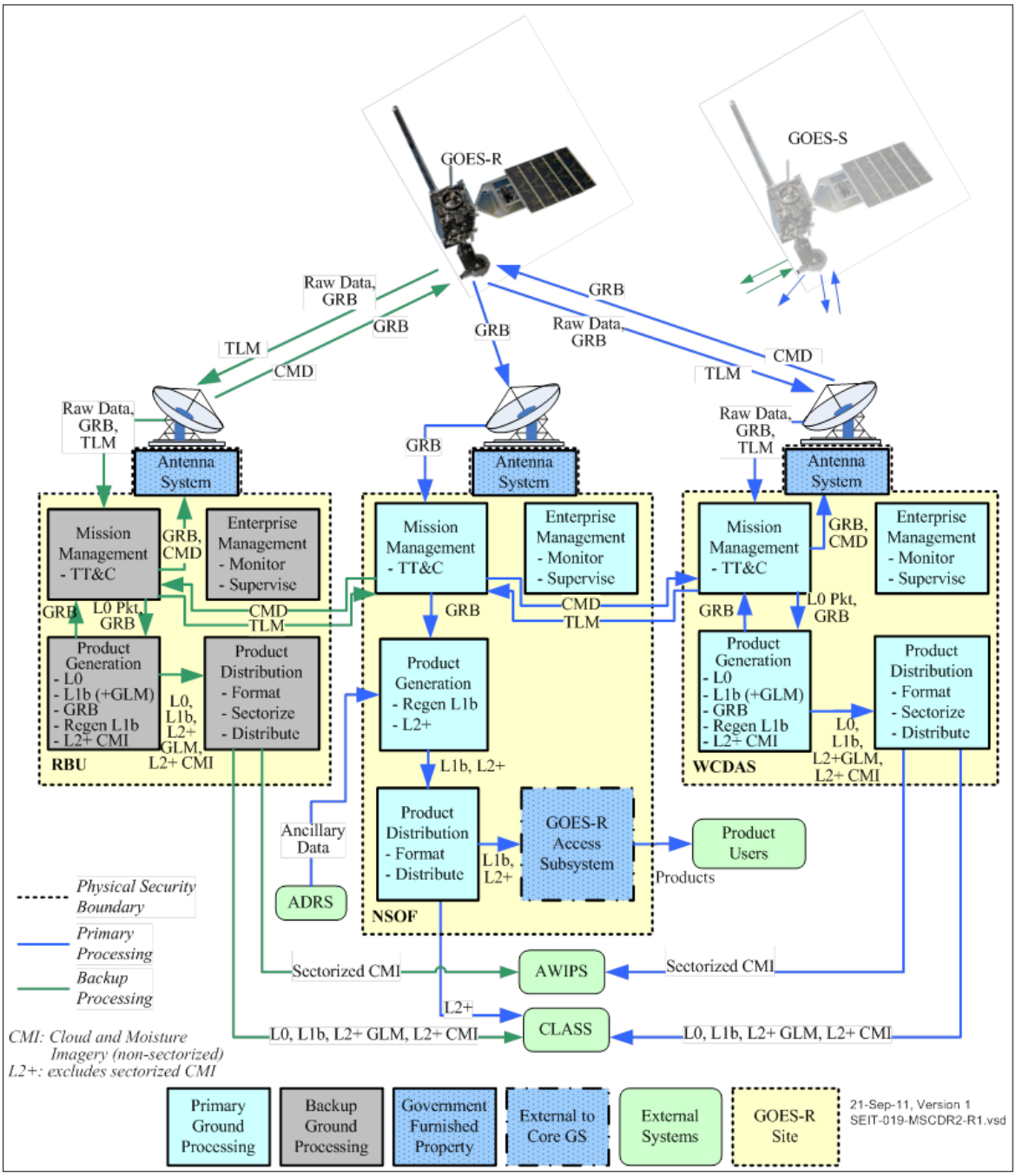

Figure 1.2-2 Ground Segment Primary Data Flow

At the RBU, the raw sensor data, as well as GRB, are received through its RF interface and processed by the PG function. The RBU is limited to the production of data to support L0, L1b, and L2+ GLM distribution to CLASS, creation and distribution of GRB, and the production of sectorized KPPs for distribution to AWIPS and non-sectorized KPPs for distribution to CLASS.

The GS includes separate development and integration and test (I&T) environments for the purposes of ongoing development and (I&T) throughout the GOES-R mission. Portions of these environments are

located at both NSOF and WCDAS to support local site development and I&T activities (Reference Master Technical Project Overview 20120413).

1.3 Document Overview

The purpose of this main volume is to provide product and data overview information including a summary of file formats, standards and conventions, product and data overviews, and a cross-reference to detailed product and data information in the other PUG volumes. The intent of providing this information is to allow users to exploit the products and data. This document also supports Government remote tele-training and public outreach requirements.

This main PUG volume includes the following sections:

- Introduction
- Applicable/Reference Documents
- Instrument Overview
- Product and Data File Formats
- Product and Data Conformance with Standards and Conventions
- Off-the-Shelf Applications and Utilities
- Summary Product and Data Descriptions
- Product and Data Filename Conventions
- Points of Contact and Primary Responsibility
- Acronym List

2.0 REFERENCE DOCUMENTS

All documents referenced in the volumes and appendices of the PUG are listed in Table 2.0. Document number, title, version, if applicable, and date are specified for each document.

Table 2.0 Reference Documents

Document Number	Title	Date
n/a	netCDF Users' Guide Version 4.1.3	June 2011
n/a	A User's Guide for the Flexible Image Transport System (FITS), Version 4.0	14 April 1997
NOST 100-2.0	Definition of the Flexible Image Transport System (FITS)	29 March 1999
n/a	HDF5 User's Guide	November 2013
n/a	Extensible Markup Language 1.0 Fifth Edition	26 November 2008
n/a	netCDF Climate and Forecast (CF) Metadata Conventions Version 1.7	*pending release*
ISO 19915:2003	Geographic Information – Metadata	5 January 2003
ISO 19115-2:2009	Geographic Information – Metadata – Part 2: Extensions for Imagery and Gridded Data	3 February 2009

Document Number	Title	Date
ISO/TS 19139:2007	Geographic Information – Metadata – XML Schema that defines implementation.	17 April 2007
ITT SSD NO. 06250/0043-5	GOES-R ABI Flight Telemetry and Command Handbook CDRL No.0043 (Rev C)	22 September 2011
GLM00447	Flight Telemetry and Command Handbook (CDRL043) Geostationary Lightning Mapper (GLM) for the Geostationary Operational Environmental Satellite (GOES) GOES-R Series (Rev A)	30 September 2010
SUVP-RQ-08-0858	Solar Ultra Violet Imager (SUVI) Flight Telemetry and Command Handbook CDRL 043 (Rev A)	1 March 2011
109743	EUV and X-Ray Irradiance Sensors (EXIS) Command and Telemetry Handbook CDRL-43 (Rev D)	23 May 2011
SEISS-D-SY043	Flight Telemetry And Command Handbook (FTCH) For The GOES-R Space Environment In-Situ Suite (SEISS) CDRL-43 (Rev C)	7 June 2010
ETSI EN 302 307	Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2) V1.2.1	April 2009
CCSDS 732.0-B-2	AOS Space Data Link Protocol Blue Book	July 2006
CCSDS 133.0-B-1	Space Packet Protocol	September 2003
ISO 13239	High-Level Data Link Control (HDLC)	15 July 2002
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Cloud and Moisture Imagery Product (CMIP) (Version 2.3)	15 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research ABI Algorithm Theoretical Basis Document For Daytime Cloud Optical and Microphysical Properties (DCOMP) (Version 2.0)	6 June 2011
160G-0173	NOAA NESDIS Center for Satellite Applications and Research Algorithm Theoretical Basis Document ABI Aerosol Detection Product (Version 2.0)	30 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research Algorithm Theoretical Basis Document for Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter (Version 2.0)	25 September 2010

Document Number	Title	Date
160G-0173	NOAA NESDIS Center for Satellite Applications and Research Algorithm Theoretical Basis Document ABI Cloud Height (Version 2.0)	7 June, 2011
160G-0173	NOAA NESDIS Center for Satellite Applications and Research Algorithm Theoretical Basis Document ABI Cloud Mask (Version 2.0)	6 June 2011
160G-0173	NOAA NESDIS Center for Satellite Applications and Research Algorithm Theoretical Basis Document GLM Lightning Cluster-Filter Algorithm (Version 2.0)	24 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Volcanic ash (Detection and Height) (Version 2.0)	15 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Cloud Type and Cloud Phase (Version 2.0)	15 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Nighttime Cloud Optical Depth, Cloud Particle Size, Cloud Ice Water path, and Cloud Liquid Water Path (Version 2.0)	15 July 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Rainfall Rate (QPE) (Version 2.0)	24 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Fire / Hot Spot Characterization (Version 2.0)	27 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Land Surface Temperature (Version 2.0)	21 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Downward Shortwave Radiation (Surface), and Reflected Shortwave Radiation (TOA) (Version 2.0)	27 September 2010

Document Number	Title	Date
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Legacy Atmospheric Moisture Profile, Legacy Atmospheric Temperature Profile, Total Precipitable Water, and Derived Atmospheric Stability Indices (Version 2.0)	September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Sea Surface Temperature (Version 2.0)	30 August 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Derived Motion Winds	30 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Hurricane Intensity	15 September 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R ABI Snow Depth Algorithm Theoretical Basis Document (Version 0.3)	13 October 2010
160G-0173	NOAA NESDIS Center for Satellite Applications and Research GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Sea Surface Temperature (Version 2.0)	20 September 2009

3.0 INSTRUMENT OVERVIEW

The six instruments on the Geostationary Operational Environmental Satellite-R series (GOES-R) offer unique observations of the environment and consist of the Advanced Baseline Imager (ABI), Geostationary Lightning Mapper (GLM), Extreme Ultra-Violet and X-Ray Irradiance Sensors (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS), and Magnetometer.

The ABI instrument is a multi-spectral channel, two-axis scanning radiometer designed to provide radiometrically calibrated and geolocated observations of the Earth. ABI bands 1-6 measure solar reflected radiance at visible and near-infrared wavelengths, and bands 7-16 measure emitted radiance from the sources at infrared wavelengths. Data availability, radiometric quality, simultaneous data collection, coverage rates, scan flexibility, and minimizing data loss due to the sun, are prime capability requirements of the ABI system. The ABI scans the Earth using three standard geographic coverage regions: Full Disk, Continental United States (CONUS), and Mesoscale. The ABI utilizes the concepts of scenes and timelines in defining its scanner operations.

The Full Disk is defined as a circle, with a 17.4 degree angular diameter from the perspective of the ABI centered at the instrument's nadir that reaches the Earth's limb. Overscan is required to deal with the non-ideal orbit and image motion compensation. CONUS is defined as a nadir-viewed rectangle 8.0215 x 4.8129 degrees, approximately 5000 E/W x 3000 North/South kilometers, in the geographic area of

10N-60N latitude and 60W-125W longitude; Mesoscale is defined as the equivalent of a 1.6043 x 1.6043 degree, approximately 1000 x 1000 kilometer region. Full Disk images are generated in ABI scanning Mode 3 and 4, while Mesoscale and CONUS images are only generated in ABI scanning Mode 3.

The X-ray Sensor (XRS) and the Extreme Ultraviolet Sensor (EUVS) are packaged together in one instrument called the EXIS. EXIS is designed to be pointed at the sun and acquiring space weather data at all times except for brief calibration and maintenance activities.

EUVS consists of three spherical grating spectrometer channels. The three channels, denoted A, B and C, give coverage in the bands of 16-37nm (1.4nm resolution), 115-135nm (1.3nm resolution) and 275-285nm (0.2nm resolution). From these, a reconstruction of the full spectrum between 5nm and 127nm will be possible.

XRS: X-ray Sensor consists of three photodiode-based photometer channels, two active (A and B) and one inactive. Channel A covers 0.05-0.4nm and channel B covers 0.1-0.8nm. The "dark" diode channel allows background subtraction. All active channels view the sun through two Be filters. Each XRS channel consists of a low-sensitivity and a high-sensitivity detector whose responses overlap in order to span the required total dynamic range. The low-sensitivity detectors are quadrant photodiodes which view the sun through a small aperture, allowing X and Y position information to be extracted for bright, localized events such as solar flares.

The GLM instrument is a single-channel, near-infrared optical detector, used to detect, locate and measure the optical pulses associated with lightning over the Full Disk Earth. The instrument has sufficient spatial and temporal resolution to allow tracking of each lightning flash within a specific storm cell and calculation of the cell's optical center over time.

The MAG instrument provides three orthogonal measurements of the geomagnetic field in space at a refresh rate of at least 0.5 seconds and has a dynamic range of ±512 nT in each of the three orthogonal axes and measures the field with a resolution of at least 0.016 nT per axis. The sampling rate of the product data is 10 Hz. This measurement data is used to map the space environment that controls charged particle dynamics in the outer region of the magnetosphere and provide information on the general level of geomagnetic activity, monitor current systems in space, and permit detection of magnetopause crossings, sudden storm commencements, and sub storms.

The SEISS instrument consists of a suite of sensors that monitors the proton, electron, and heavy ion fluxes at geosynchronous orbit. The information provided by the SEISS is critical for assessing the radiation hazard to astronauts and satellites. In addition to hazard assessment, the information from the SEISS can be used to warn of high flux events, mitigating any damage to radio communication. The SEISS instrument suite consists of the Energetic Heavy Ion Sensor (EHIS), the Magnetospheric Particle Sensor -High and Low (MPS-HI and MPS-LO), and the Solar and Galactic Proton Sensor (SGPS). There are two SGPSs in each suite, one looking east and one looking west.

The SUVI instrument is designed to provide a view of the solar corona, taking the Full Disk solar images at high cadence around the clock, except for brief periods during an eclipse, in the soft XUV to EUV wavelength range. Available combinations of exposures and filters allows the coverage of the entire dynamic range of solar XUV features, from coronal holes to X-class flares, as well as the estimate of temperature and solar emissions.

4.0 PRODUCT AND DATA FILE FORMATS

4.1 Network Common Data Format (netCDF)

The netCDF file format is a general-purpose scientific data file format. It provides considerable flexibility, and includes Application Programmer Interfaces (APIs) for several programming language including, but not limited to Java, C++, C, and Fortran.

GOES-R netCDF product and data files use the netCDF-4 format. netCDF-4 supports both the enhanced and classic data model. netCDF-4 uses an enhanced version of the Hierarchical Data Format version 5 (HDF5) as the storage layer. netCDF-4 files are created with the HDF5 library, and can be read without the netCDF-4 interface.

The enhanced data model includes contemporary data structures, user defined data types, and groups. Groups allow data to be organized into hierarchies, and define a separate namespace. Other than a few cases, such as using multiple unlimited dimensions in Level 0 product files, instrument calibration data files, and GLM L2+ Lightning Detection product files, GOES-R product data is not of sufficient complexity to warrant the use of the enhanced data model. For this reason, and because both the CF metadata conventions makes use of the classic data model, and the off-the-shelf toolset for the classic data model is more extensive, the classic data model is used. Refer to Figure 4.1, netCDF Classic Data Model.

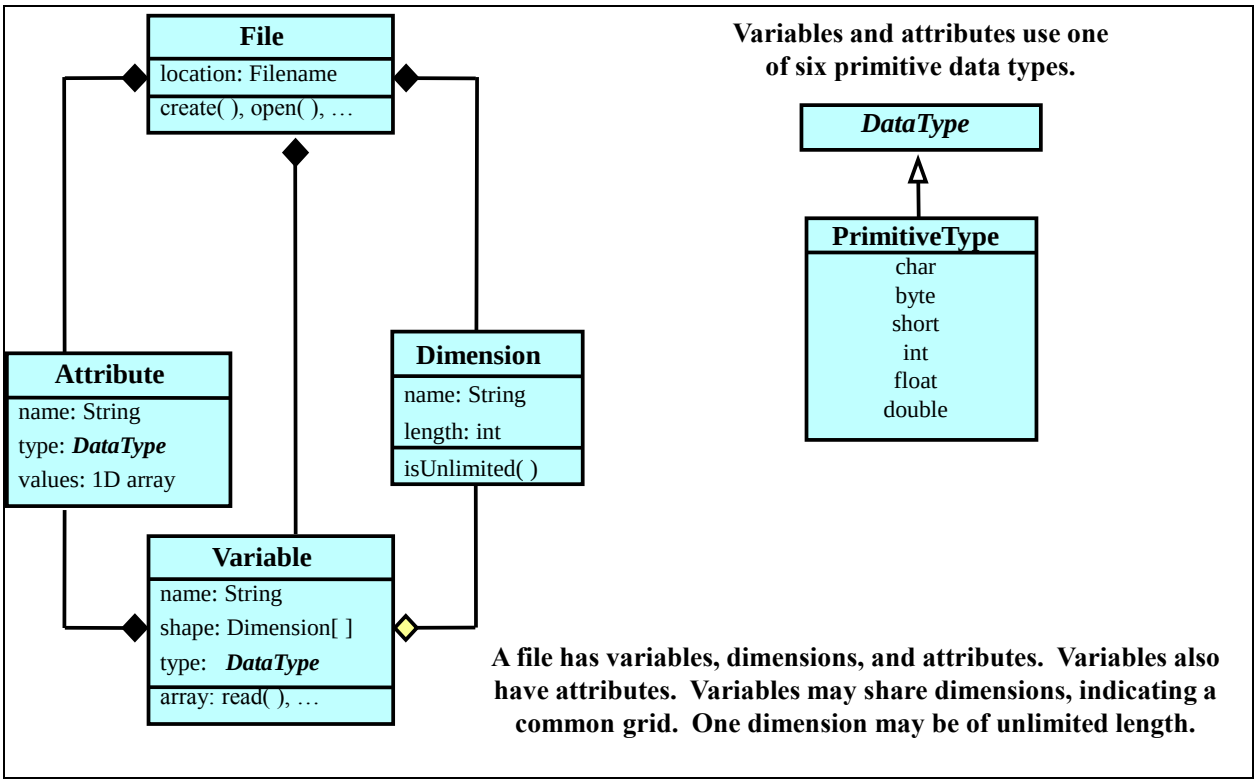

Figure 4.1 netCDF Classic Data Model

A netCDF file is composed of dimensions, variables, and attributes. Rather than user applications accessing file sectors and records, they make use of an API allowing the creation and access of dimensions, variables, and attributes. This API provides the user applications with a logical interface to access the content of files, and insulates the applications from the physical addressing where specific data in a file is stored.

Dimensions are used to size dimensional variables (i.e. arrays). Attributes can be attached to the file (i.e. global attributes) or a file's variables. Attribute conventions have been established to promote interoperability. These attribute convention are discussed in the Product and Data Conformance with Standards and Conventions paragraph that follows.

Some GOES-R products are very large. For example, the ABI L1b/L2+ full disk and CONUS gridded product files are tens to hundreds of megabytes or larger. To improve performance of the user applications when accessing product files, chunking provided by the HDF5 storage layer is used. The

chunking configured in these large files is based on a tiling of the regions associated with product data, which is anticipated to align with the typical access pattern.

In addition to chunking, the large netCDF-4 product files are reduced in size using compression/decompression capabilities in the HDF5 storage layer. netCDF-4 ABI L1b/L2+ gridded product files are compressed. This reduction in size allows less storage and bandwidth to be required by access, archive, and user systems, and enabling network. The netCDF-4 APIs insulate the user applications from the complexity associated with compression. A small performance penalty is incurred when compressed netCDF-4 files are read.

Additional details on the netCDF-4 file format are found in the Unidata netCDF User's Guide (NUG). An on-line version of the NUG is located at http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.html. A document version of the NUG is located at http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.pdf.

GOES-R netCDF-4 product and files are specified using the XML-based netCDF Markup Language (NcML) version 2.2. Additional details on NcML is located at http://www.unidata.ucar.edu/software/thredds/current/netcdf-java/ncml/.

4.2 Flexible Image Transport System (FITS) Format

****** This paragraph will be supplied in PUG version C.3. ******

4.3 Unix Text File Format

The Unix text file format is used for in Level 1b and Level 2 processing parameter files, and is also embedded in GRB metadata packets.

The Unix text file format is a sequence of lines (i.e. records), potentially variable in length, of electronic text. For the GOES-R ground system, the electronic text, newline, and end-of-file characters conform to the American Standard Code for Information Interchange (ASCII). At the end of each line is the newline character. At the end of file, there is an end-of-file character.

The Unix text file format is used in a few Level 1b and 2 processing parameter files. The Unix text file format, less the end-of-file character, is embedded in GRB metadata packets to store the XML-based netCDF Markup Language (NcML) representation of the netCDF file specifications, which includes the values for product metadata.

4.4 Hierarchical Data Format (HDF)

The HDF file format is a general purpose scientific data file format. It provides considerable flexibility and includes Application Programmer Interfaces (APIs) for several programming language including Java, C++, C, and Fortran.

The GOES-R ground system uses version 5 of HDF (i.e. HDF5). This format is used for several Level 1b processing parameter files.

An HDF file is composed of datasets, attributes, and other constructs. Rather than user applications accessing file sectors and records, they make use of an API allowing the creation and access of datasets, attributes, and other constructs. This API provides the user applications with a logical interface to access the content of files, and insulates these applications from the physical addressing where specific data in a file are stored.

Note that because netCDF-4 uses HDF5 for its storage layer, off-the-shelf HDF software tools can be used to provide rudimentary display and access functionality for GOES-R product files.

An HDF5 User's Guide is available, and is located at http://www.hdfgroup.org/HDF5/doc1.6/UG/.

5.0 PRODUCT AND DATA CONFORMANCE WITH STANDARDS AND CONVENTIONS

5.1 netCDF Users' Guide (NUG) Conventions

The NUG includes several general recommendations for attributes in a netCDF file potentially applicable to all GOES-R products and data. These attribute conventions are identified and described in Table 5.1, NUG Recommended Attributes.

Table 5.1 NUG Recommended Attributes

Attribute Name	*Attribute Definition*
title	A global attribute that is a character array providing a succinct description of what is in the product data file.
Conventions	If present, a global attribute is a character array (i.e. string) for the name of the conventions followed by the product. This attribute is used in the ABI L1b/L2+ products that comply with the CF Metadata Conventions.
long_name	A long descriptive name.
_FillValue	A scalar value of the same type as the variable to which it is attached that identifies missing data.
valid_range	A comma-delimited vector of two numbers specifying the minimum and maximum valid values for the variable to which it is attached.
scale_factor and add_offset	If present, the data is first scaled (i.e. multiplied) before the offset is added. Scale factor and add offset are used together to provide simple data compression to store floating-point data as small integers in a product data file. In GOES-R netCDF product files, when scale factor and add offset are used for packing, the associated variable (containing the packed data) is typically of type short, whereas the unpacked values are intended to be of type float or double. The attributes scale_factor and add_offset are of the type intended for the unpacked data.
units	A character string that specifies the units used for the variable's data. Unidata has developed a freely-available library of routines to convert between character string and binary forms of unit specifications and to perform various useful operations on the binary forms. Using the recommended units syntax permits data represented in conformable units to be automatically converted to common units for arithmetic operations. The library and associated documentation are available at http://www.unidata.ucar.edu/packages/udunits/.

5.2 Attribute Convention for Data Discovery (ACDD)

The Attribute Convention for Data Discovery (ACDD) is one area of support in which Unidata recommends a specification of netCDF attributes to be used to catalog environmental science data in support of efficient access. These attributes correspond to general discovery metadata content to allow interoperability with other metadata standards such as Thematic Real-time Environmental Distributed Data Services (THREDDS) and the ISO 19115 standard.

GOES-R netCDF products and data comply with the ACDD version 1.0.

There are four categories of ACDD metadata:

- Highly recommended global attributes.
- Recommended global attributes.
- Suggested global attributes.
- Highly recommended attributes within variable.

The attributes and variables being referred to here are netCDF dataset components used to construct product and data files. The highly recommended attributes within variables category is discussed in paragraph 5.3, Climate and Forecast (CF) Metadata Conventions, that follows.

Table 5.2 identifies the highly recommended, recommended, and suggested ACDD global attributes. The attributes in plain text are used in GOES-R products and data where applicable. The attribute names in italic font are not used in GOES-R products and data. In these cases, the description column provides the rationale for them not being included.

Table 5.2 ACDD Global Attributes

Highly Recommended	
Attribute Name	**Description**
title	A short description of the dataset
summary	A paragraph describing the dataset
keywords	A comma separated list of key words and phrases

Recommended	
Attribute Name	**Description**
id	The combination of the "naming authority" and the "id" should be a globally unique identifier for the dataset.
naming_authority	
keywords_vocabulary	If you are following a guideline for the words/phrases in your "keywords" attribute, put the name of that guideline here.
cdm_data_type	The THREDDS data type appropriate for this dataset.
history	Provides an audit trail for modifications to the original data. *Not applicable to GOES-R products and data.*
comment	Miscellaneous information about the data. *Metadata for GOES-R products and data is extensive. No miscellaneous information has been identified.*
date_created	The date on which the data was created.
creator_name	The data creator's name, URL, and email. The "institution" attribute will be used if the "creator_name" attribute does not exist. *GOES-R metadata includes "institution".*
creator_url	
creator_email	
institution	
project	The scientific project that produced the data.
processing_level	A textual description of the processing (or quality control) level of the data.
acknowledgement	A place to acknowledge various type of support for the project that produced this data. *Not applicable to GOES-R end-products.*
geospatial_bounds	Describes geospatial extent using any of the geometric objects (2D or 3D) supported by the Well-Known Text (WKT) format.

Recommended	
Attribute Name	**Description**
	This is a new ACDD attribute added after the GOES-R metadata was defined.
geospatial_lat_min *geospatial_lat_max* *geospatial_lon_min* *geospatial_lon_max*	Describes a simple latitude/longitude bounding box. geospatial_lat_min specifies the southernmost latitude; geospatial_lat_max specifies the northernmost latitude; geospatial_lon_min specifies the westernmost longitude; geospatial_lon_max specifies the easternmost longitude of the bounding box. The values of geospatial_lon_min and geospatial_lon_max reflect the actual longitude data values. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian or Prime Meridian), to geospatial_lon_min. *GOES-R netCDF end-products use the following attributes:* *geospatial_westbound_longitude,* *geospatial_northbound_latitude,* *geospatial_eastbound_longitude and* *geospatial_southbound_latitude* *as well as* *geospatial_lat_center,* *geospatial_lon_center,* *geospatial_lat_nadir and* *geospatial_lon_nadir.*
geospatial_vertical_min *geospatial_vertical_max*	Describes a simple vertical bounding box. *Not applicable to GOES-R end-products.*
time_coverage_start time_coverage_end *time_coverage_duration* *time_coverage_resolution*	Describes the temporal coverage of the data as a time range. *Duration and resolution were considered redundant information to time coverage start and end.*
standard_name_vocabulary	The name of the controlled vocabulary from which variable standard names are taken.
license	Describes the restrictions to data access and distribution.

Suggested	
Attribute	**Description**
contributor_name *contributor_role*	The name and role of any individuals or institutions that contributed to the creation of this data. *Not applicable to GOES-R end-products.*
publisher_name *publisher_url* *publisher_email*	The data publisher's name, URL, and email. The publisher may be an individual or an institution. *The archive or Data Center may add this metadata.*
date_modified	The date on which this data was last modified. *Not applicable to GOES-R end-products.*
date_issued	The date on which this data was formally issued. *Considered redundant with "date_created" for GOES-R end-*

Suggested	
Attribute	**Description**
	products.
geospatial_lat_units	Further refinement of the geospatial bounding box can be provided by using these units and resolution attributes. *GOES-R products and data use the attribute: "spatial_resolution" which is the resolution at nadir, as applicable. Vertical extents are not defined for GOES-R products and data.*
geospatial_lon_units	
geospatial_lat_resolution	
geospatial_lon_resolution	
geospatial_vertical_units	
geospatial_vertical_resolution	
geospatial_vertical_positive	

Refer to http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_(ACDD) for additional details.

5.3 Climate and Forecast (CF) Metadata Conventions

The ABI Level 1b and 2+ products conform to the CF Metadata Conventions version 1.7. The CF conventions are designed to promote the processing and sharing of files created with the netCDF Application Programming Interface (API). The conventions define metadata that provide a definitive description of what the data in each variable represents, and of the spatial and temporal properties of the data. This enables users of data from different sources to decide which quantities are comparable, and facilitates building applications with comprehensive extraction, regridding, and display capabilities.

The CF conventions applicable to the ABI Level 1b and 2+ products include metadata that provides:

- Identification and semantics of environmental data in gridded (e.g. imagery) and discrete sampling geometry form.
- Extensions to the netCDF User's Guide (NUG) defined coordinate variables, which enable locating environmental data in space and time, and that support application-specific coordinates that are meaningful in the science domains associated with different products.
- Precise definition of each variable via specification of a standard name and its units of measure.
- Spatial coordinates for gridded and discretely sampled data.
- Descriptions of coordinate intervals, multidimensional cells, and data values that are representative of a spatial or temporal based interval or cell.

The netCDF interface enables but does not require the creation of self-describing datasets. The purpose of the CF conventions is to require conforming datasets to contain sufficient metadata so that they are self-describing in the sense that each variable in the file has an associated description of what it represents, including units of the physical quantity if appropriate, and that each value can be located in space and time. Note that space not only refers to physical location but can refer to wavelength within the electromagnetic spectrum, atmospheric pressure levels, location relative to sun or the sensing platform, and other points of reference meaningful to the particular data quantity.

The CF conventions are based on the netCDF classic data model, and do not use enhanced data model constructs such as groups and structures. The netCDF classic data model is discussed above in Paragraph 4.1.

While this paragraph is intended to provide the essential background information required to interpret and use the conforming ABI L1b/L2+ products, there may be cases when additional technical details and depth available in the CF Metadata Conventions are useful to product users. The CF Metadata Conventions document is located at http://cf-pcmdi.llnl.gov/documents.

The remainder of this paragraph and subordinate paragraphs provide the essential CF conventions related background information required to interpret and use the ABI L1b/L2+ products.

The CF metadata convention topics discussed in the subordinate paragraphs that follow are defined in the Table 5.3, CF Metadata Convention Topics.

Table 5.3 CF Metadata Convention Topics

CF Conventions Topic	*Summary Description*
Standard Names	Name identifying a specific physical quantity.
Units	Identity of measure associated with physical quantities.
Ancillary Data	Association between variables to express that one data variable provides metadata about the individual values of another data variable.
Flags	Integer data variables whose possible values are enumerated and associated with specific meanings.
Coordinates	One-dimensional array and scalar variables associated with data variables and enable their data elements to be located in space and time.
Grid Mappings and Projections	Provide the means to project data values to locations on the earth.
Cells	Comprehensively describes the extent of a data value when it is associated with a spatio-temporal volume.
Discrete Sampling Geometries	Provides the means to represent non-gridded environmental data.
Packed Data	Supports the reduction of product file size through the use of scaled integers rather than floating point for data values.

These topics are discussed in the CF Metadata Conventions document in greater detail. This document also provides examples for each of these topics.

5.3.1 Standard Names

A standard name allows users of data from different sources to determine whether quantities are comparable. All GOES-R ABI Level 1b and 2+ quantities in the products that could possibly be compared or fused by other application software systems have standard_names.

Standard names associated with dimensional quantities have canonical units, which are precise units of measure for the physical quantity. The units attribute for a variable with a standard_name must use the canonical units or units that are physically equivalent. Note that there are CF conventions for dimensionless quantities and are discussed in the Units paragraph that follows.

A standard name is associated with a variable via the attribute standard_name, which is a string value composed of a standard name. When an ABI L1b/L2+ product data variable does not have a standard name, the attribute long_name, whose value is an ad-hoc string value, is the sole data variable attribute describing its content.

The complete set of standard names, their descriptions and canonical units, and additional documentation is located at http://cf-pcmdi.llnl.gov/documents/cf-standard-names/.

5.3.2 Units

The attribute units capture the identity of the measure units associated with data quantities. The attribute units is a NUG defined attribute, but discussed here to further elaborate the usage of this attribute in the ABI L1b/L2+ products.

The attribute units is included for all variables except boundary variables, which are defined in the Cells paragraph below, and container variables, such as the grid mapping variable, which is defined in the Grid Mappings and Projections paragraph.

The units for dimensional quantities conform to the Unidata UDUNITS-2 package. UDUNITS-2 quantities, descriptions, documentation, and library software is located at http://www.unidata.ucar.edu/software/udunits/udunits-2/udunits2.html/. Conventions have been established for dimensionless quantities: "percent" and "count". When the quantity is dimensionless and not "percent" or "count", "1" is used.

5.3.3 Ancillary Data

Ancillary data provides for associations between variables to indicate that one data variable provides metadata about the individual values of another data variable. An example of ancillary data is a data quality flag variable that has a relationship with its primary data variable(s).

The attribute ancillary_variables is used to express these types of relationships. It is a string attribute whose value is a blank separated list of variable names. This attribute is attached to a primary data variable and contains the variable name(s) of the ancillary data variable(s) to provide the linkage indicating the association between the variables. The nature of the relationship between variables associated via ancillary_variables is determined by other attributes.

5.3.4 Flags

Flag variables, which are enumeration types, provide a means to associate an integer value with a meaning. Every ABI L1b/L2+ product has at least one flag variable, the data quality variable that is dimensioned to correspond to its associated data variable. In some case, flag variables are used for the primary data in a product, such as is the case with the Aerosol Detection product.

The attributes flag_values, flag_mask, and flag_meanings support making variables that contain flag values self-describing. Status codes and Boolean condition flags may be expressed with different combinations of flag_values and flag_masks attribute definitions.

There are two distinct methods used in the specification of a flag variable for ABI L1b/L2+ products:

1) The declaration of flag_values and flag meanings attributes when a status flag consists of mutually exclusive coded values. The flag_values attribute is the same data type as the variable to which it is attached, and contains a list of the possible flag values. The flag_meanings attribute value is a string whose value is a blank separated list of descriptive words or phrases, one for each flag value.
2) The declaration of flag_masks, flag_values and flag meanings attributes describe a blend of independent Boolean conditions and enumerated status codes. Using this method, a single flag value supports indication of multiple statuses. The flag_masks and flag_values attributes are both the same type as the variable to which they are attached. A flagged condition is identified by a bitwise AND of the variable value and each flag_masks value; a result that matches the flag_values value indicates a true condition. Repeated flag_masks define a bit field mask that identifies a number of status conditions with different flag_values. The flag_meanings attribute is defined as above, one for each flag_masks bit field and flag_values definition. Each flag_values and flag_masks value must coincide with a flag_meanings value.

The attribute standard_name for the flag variables, which contain an indication of quality, has a value of status_flag. This describes the ancillary data relationship existing between the data and the flag variable.

Specific examples of the use of these flag attributes are located in Chapter 3.5 Flags of the CF Metadata Conventions.

5.3.5 Coordinates

Coordinate variables provide the capability to locate individual data values in space and time. Space not only refers to physical location but can refer to wavelength within the electromagnetic spectrum, atmospheric pressure levels, location relative to sun or the sensing platform, and other points of reference meaningful to a particular data quantity.

The CF conventions call out coordinate variables and auxiliary coordinate variables. The distinction is a result of the coordinate variable definition provide in the NUG. In the case of coordinate variables, the name of the dimension and the coordinate variable are the same. When this is not the case, the variable is an auxiliary coordinate variable, except in the case where the coordinate variable is scalar, which is discussed in this paragraph below.

Coordinate variable values are the coordinates. Typically, geo-location coordinate values are in units of latitude and longitude, but can be in other units such as meters, or, in the case of the products on the ABI fixed grid, radians. The geo-location coordinate variables for the ABI L1b/L2+ gridded products are discussed in further detail in the ABI Fixed Grid paragraph in the Level 1b, GRB, and Level 2+ volumes of the PUG.

A set of related CF metadata constructs are provided to allow user applications to map geolocation coordinate values, such as radians, to latitude and longitude. These related constructs are discussed in paragraph 5.3.6, Grid Mapping and Projections. Other examples of coordinate variables include time and electromagnetic radiation. The CF compliant representations are discussed in detail in paragraph 4.4, Time Coordinates of the CF Metadata Conventions.

The value of the attribute coordinates is a blank separated list of the names of auxiliary coordinate variables, and optionally the coordinate variable names. Although optional, all ABI L1b/L2+ product data variables identify both types of coordinate variables in the coordinate attribute specification.

For the gridded ABI L1b/L2+ products, the fixed grid or lat/lon coordinates, and atmospheric pressure level coordinate, in the case of the Vertical Temperature and Pressure Profile products, are dimensioned coordinate variables where the name of the dimension is the same as the coordinate variable name.

For the gridded ABI L1b/L2+ products, time is a scalar coordinate variable because the image is generated over a single reporting interval. In addition, there are other scalar coordinate variables and scalar auxiliary coordinate variables including, but not limited to, electromagnetic radiation wavelength, ABI channel number, solar zenith angle, and platform zenith angle. It is important to note that cell related CF conventions are used to capture the volume extent of some of these scalar coordinate variables, including time, and is described in paragraph 5.3.7, Cell, below.

Scalar coordinate variables do not have to be associated with a data variable array dimension. When scalar coordinate variables are used their names do need to be included in the attribute coordinate string value to identify that the scalar variable is a coordinate variable. In the case of data variables where the electromagnetic radiation wavelength and ABI band are included as coordinates, these variables are declared as one dimensional arrays with "dimension = 1" despite the fact that they are scalar values to indicate the dependency that exists between ABI band number and wavelength.

Coordinates for the non-gridded ABI L1b/L2+ products, Derived Motion Winds and Hurricane Intensity Estimate, are discussed in paragraph 5.3.7.3, Discrete Sampling Geometry.

5.3.6 Grid Mappings and Projections

Grid mappings coupled with geo-location coordinate variables provide the means to determine the latitude and longitude of a data point on the ABI fixed grid whose native coordinate values are the E/W scanning angle and N/S elevation angle in units of radians relative to the location of the satellite. For all

ABI gridded L1b/L2+ products, the names of these coordinate variables are x and y for the E/W scanning angle and N/S elevation angle, respectively.

The attribute grid_mapping is used to describe the mapping between the geo-location coordinate variables and latitude and longitude coordinates. This attribute is attached to data variables whose values are associated with specific earth locations. The attribute is a string value containing the name of another variable in the file that provides the description of the mapping via a collection of attached attributes. This variable is called a grid mapping variable and is of arbitrary type since it contains no data. Its purpose is to act as a container for the attributes that define the mapping.

The one attribute that all grid mapping variables must have is grid_mapping_name, which takes a string value that contains the mapping's name. In the case of ABI L1b/L2+ gridded products whose data is on the ABI fixed grid projection, the grid_mapping_name value is "geostationary". The other attributes required for this projection are those that specify the parameters associated with the selected earth model to use for the GOES-R ABI L1b/L2+ products, the Geodetic Reference System 1980 (GRS 80), lat/lon origin of the projection, and a parameter that identifies the scanning pattern associated with the ABI instrument.

To make use of a grid mapping to directly calculate latitude and longitude values it is necessary to associate the coordinate variables with the independent variables of the mapping. This is done by assigning the standard_names projection_x_coordinate and projection_y_coordinate to the geo-location coordinate variables. Off-the-shelf, open-source projection software is available to perform the "geostationary" grid mapping. Additional details on this software is located in the ABI Fixed Grid paragraph in the Level 1b, GRB, and Level 2+ volumes of the PUG.

In the case of the ABI L2+ shortwave radiation products, and the two ABI L2+ non-gridded products, Derived Motion Winds and Hurricane Intensity Estimate, the grid mapping is used to solely identify the GRB 80 earth model parameters. The name of this grid mapping is "latitude_longitude".

5.3.7 Cells

When data values do not represent point values of a field but instead represents some characteristic of the field within cells of finite "volume," a complete description of the variable includes metadata that describes the domain or extent of each cell, and the characteristic of the field that the cell values represent.

Two distinct cell related CF metadata constructs are employed in the ABI L1b/L2+ products.

1) Cell boundary constructs provide the means to identify the specific "volume" associated with the "volume" of space or interval of time associated with data values.
2) Cell methods constructs provide the means to describe the characteristics of data values that are associated with a cell.

These constructs are discussed in the following paragraphs.

5.3.7.1 Cell Boundaries

To represent cells, the attribute bounds is used in the specification of the appropriate coordinate variable(s). The value of bounds is the name of the variable that contains the vertices of the cell boundaries. This type of variable is referred to as a boundary variable. A boundary variable has one more dimension than its associated coordinate or auxiliary coordinate variable. The additional dimension is the most rapidly varying one, and its size is the maximum number of cell vertices. Since a boundary variable is considered to be part of a coordinate variable's metadata, it is not necessary to provide it with attributes such as long_name and units.

An example of the use of cell boundaries in ABI L1b/L2+ products is the time coordinate variable. The ABI L1b/L2+ product design associates an interval of time with the image. The time coordinate variable value is the mid-point in time of the image and the time boundary variable values are the start and end time associated with the sensing period.

The data values associated with ABI L1b/L2+ gridded data (i.e. imagery) represent the environmental condition of an area on the earth corresponding to the resolution of the product. The attribute resolution is used to identify the area associated with a grid data point (i.e., imagery pixel). This attribute is used in the specification of the applicable data variable. The value of the attribute is a string containing the names of the geo-location coordinate variables for the E/W scanning angle and N/S scanning angle with each associated with the resolution of the data values in the native ABI fixed grid units, radians. For example, the specification of this attribute for a 2 km (i.e., 0.000056 radian) fixed grid product is resolution = "y: 0.000056 rad x: 0.000056 rad".

Note that variable name for the E/W scanning angle and N/S elevation angle are "x" and "y", respectively.

Also note that the attribute resolution is not yet a CF metadata convention.

5.3.7.2 Cell Methods

The attribute cell_methods provide the means to describe the following characteristics of celled ABI L1b/L2+ data values:

- Whether the data value is associated with (a) an individual observation or moment in time (i.e. point), (b) summation of observations or time interval (i.e. sum), or (c) a statistic associated with a cell of observations (e.g. mean).
- Spacing of the cell's constituent original observation data values.
- Statistics applying to portion of cells.
- Non-standard, GOES-R specific characteristics.

The value for this attribute has components that allow for the specification of all these characteristics. This is a string attribute composed of a list of blank-separated words of the form "name: method". Each "name: method" pair indicates that for an axis identified by name, the cell values representing the field have been determined or derived by the specified method. For example, if data values are associated with a moment (i.e. point) in time, this is indicated with cell_methods="t: point", assuming that the name of the time dimension variable is "t".

In the specification of the attribute cell_method, "name" can be a dimension of the variable, a scalar coordinate variable, a valid standard_name, or the word "area". For GOES-R ABI L1b/L2+ products, "name" can be the time, platform zenith angle, solar zenith angle, or latitude scalar coordinate variables. For those ABI L2+ products where valid data values are constrained by the angle of the satellite or sun, or latitude, cell methods are used to express this. The word "area" is used for "name" to identify the combination of the horizontal coordinates. For example, "area" for ABI L1b/L2+ products on the fixed grid, identifies the area identified by the its geo-location coordinate variables with names "x" and "y", for the E/W scanning angle and N/S elevation angle, respectively.

In the specification of the attribute cell_method, "method" can take on the value of point, sum, minimum, maximum, mean, and standard_deviation for ABI L1b/L2+ products. The method applies only to the axis designated in cell_methods by name, and different methods may apply to other axes.

Proper assignment of the "method" depends on whether the quantity is extensive, which depends on the size of the cell, or intensive, which does not. For the ABI L1b/L2+ primary physical quantity gridded data, the data values are expressed as instantaneous (i.e. point) values in space and time. For ABI L1b/L2+ product-level metadata, which are often statistics associated with the entire image, "method"

takes on the specific type of statistic (i.e. minimum, maximum, etc.) for the "area" axis, and "sum" for the time axis because the celled data quantity is a statistic associated with the sensing period associated with the entire image.

For the ABI L1b/L2+ product-level summary statistics, the spacing of the original data used to generate the statistic is identified after the "method" using the "interval" keyword followed by the actual interval, which is encapsulated in parentheses. For ABI L1b/L2+ gridded products, the actual interval is expressed as the resolution of the original data (e.g. 0.000056 radians).

For some ABI L2+ products, the product-level statistics do not apply to the entire image (i.e. cell). In this case, the attribute cell_methods includes a string of the form "name: method where type". For example, "name" could be "area" and "type" may be any of the strings permitted for a variable with a standard_name of area_type. The complete set of area_types that conforming to the CF metadata conventions is located at http://cf-pcmdi.llnl.gov/documents/cf-standard-names/area-type-table/2/area-type-table.html.

Generally, when product-level statistics are generated, not all data values in the image are used. For example, it is often the case that only data points of good quality are used when generating statistics. The value for the attribute cell_method can include non-standard information, and this feature is used to express system-unique constraints associated with the calculation of cell data values. The "comments" keyword, which is encapsulated in the same set of parentheses as the "interval" keyword is used to express these types of constraints.

An example that makes use of all the components and keywords of the attribute cell_methods is included here. This value for attribute cell_methods that follows is associated with the product-level statistic for the aerosol optical depth average quantity. The standard_name of this quantity is "atmosphere_absorption_optical_thickness_due_to_ambient_aerosol".

cell_methods = "solar_zenith_angle: sum t: sum area: mean (interval: 0.000056 rad comment: good quality pixels only) where land"

Explanation: solar_zenith_angle and t are scalar coordinate variables for this statistic. These coordinate variables have an associated boundary variable to capture the solar zenith angle range (i.e. 0 to 90 degrees) for which image data points are used in the calculation of the average value, and the period of time associated with observing the scene. The method "sum" is used for both of these scalar coordinate variables because the quantity is dependent on the size of the solar zenith angle and time cells. The area axis, which identifies the two horizontal coordinates, has a method of "mean" to indicate the quantity is the average value. The interval keyword identifies the spacing of the original data (i.e. 0.00056 radians). The non-standard portion, which is identified with the "comment" keyword, indicates that only pixels of good quality are used in the calculation. The "where land" portion of the attribute cell_methods value indicates that the calculation uses pixels on land only.

Additional details on cell methods are located in Chapter 7 of the CF Metadata Conventions.

5.3.7.3 Discrete Sampling Geometries

Two of the ABI Level 2 products are not gridded, Derived Motion Winds and Hurricane Intensity Estimate. The CF metadata conventions include constructs to identify and capture the semantics of discrete sampling geometries, which are typically "paths" through space and time, but can also be collections of the same type of data at arbitrary locations.

There are several types of discrete sampling geometries. The type of a discrete sampling geometry is referred to as its featureType. The featureTypes for Derived Motion Winds and Hurricane Intensity Estimate are "point" and "trajectory", respectively. A featureType of point is characterized by there being individual data points in the product that have no implied coordinate relationship to other points. A featureType of trajectory is characterized by there being a series of data points along a path through space

with monotonically increasing times. Both of these product types include collections of features. A feature is a single instance of a discrete sampling geometry. The Derived Motion Winds product contains a collection of wind vectors. The Hurricane Intensity Estimate product, which includes all the characteristics of the cyclone over its life-cycle, contains a collection of reports where each report contains the data and metadata, including spatiotemporal information, associated with an execution of the hurricane intensity algorithm.

The syntax of the netCDF file specification for these two featureTypes as they relate to the Derived Motion Winds and Hurricane Intensity Estimate products is very similar. For each product, there are one dimensional data variables, each containing a data quantity associated with the product, and a set of one dimensional coordinate variables that capture the location of the data quantities in space and time. The CF Metadata Conventions refer to these one-dimensional coordinate variables as instance variables because they provide the metadata that differentiates individual features. The data and coordinate/instance variables are related through the use of the subscript associated with their single dimension. This dimension is referred to as the instance dimension. The subscript identifies the particular wind vector in the case of the Derived Motion Winds product, and the hurricane location at a particular time in the case of the Hurricane Intensity Estimate product.

The attribute coordinates is attached to every data variable. Its value identifies the coordinate/instance variables needed to locate the data in space and time.

Additional details on discrete sampling geometries methods are located in Chapter 9 of the CF Metadata Conventions.

5.3.7.4 Packed Data

Many of the ABI L1b/L2+ products use 16-bit scaled integers (i.e. shorts) for physical data quantities rather than 32-bit floating point values to minimize the size of the product files. The NUG defined attributes, scale_factor and add_offset, are used to allow conversion to and from the actual value associated with the physical quantity. User applications must first apply the scale_factor and then apply the add_offset to the 16-bit scaled integer using multiplication and addition, respectively.

The CF metadata conventions are more restrictive than the NUG with respect to the use of the scale_factor and add_offset attributes; ambiguities and precision problems related to data type conversions are resolved by these restrictions. If the scale_factor and add_offset attributes are of a different data type from the variable (containing the packed data), which is the case for ABI L1b/L2+ scaled integer products, then the unpacked data matches the type of these attributes, which must both be of type float. An additional restriction in this case is that the variable containing the packed data must be of type byte, short, or int. In addition, the attributes _Fill Value and valid range defined in the NUG must be of the same data type as the packed data.

5.3.8 Flexible Image Transport System (FITS) Standard

****** This paragraph will be supplied in PUG version C.3. ******

5.3.9 extensible Markup Language (XML) Standard

XML is a subset of the Standard Generalized Markup Language (SGML) designed for ease of implementation and use. XML is text based, and provides a hierarchical structure, and tag, value pairs for labeling and defining data. The XML in GOES-R products and data conform to the ASCII standard.

The primary use of XML in GOES-R products and data is for GRB metadata packets that encapsulate the XML-based NMS representation of the netCDF file specifications, including the values for product metadata.

Additional details on XML are located in the extensible Markup Language specification at http://www.w3.org/TR/xml/.

5.3.10 ISO Series Metadata Standards

ISO series metadata is associated with each type of GOES-R products and data made available to users.

The ISO series metadata conforms to several ISO standards:

- ISO 19115:2003, Geographic Information – Metadata.
- ISO 19115-2:2009, Geographic Information – Metadata – Part 2: Extensions for Imagery and Gridded Data that define metadata content, and a technical specification.
- ISO/TS 19139:2007, Geographic Information – Metadata – XML Schema that defines implementation.

ISO 19115 and 19115-2 contain many normative reference 19xxx standards. Normative standards provide guidelines for properly implementing the main standards. Refer to ISO 19115 and 19115-2 documentation for further information on their normative reference standards.

ISO 19115 contains fourteen UML packages. Each package contains a number of other packages and entities:

- Metadata entity set information (package) – the root level that contains information about the metadata file itself and contains the following packages:
    - Identification information (package) – information to uniquely identify the data and the following entities:
        - Format of the data
        - Browse graphic – graphic overview of the data
        - Usage – specific uses of the data
        - Constraints (package) – constraints placed on the resource
            - Legal constraints
            - Security constraints
        - Keywords – keywords describing the resource
        - Maintenance Information – how often the data is scheduled to be updated and the scope of the update
        - Aggregate Information – information about datasets that are aggregate parts of the dataset that the metadata describes
    - Constraint information – contains information concerning the restrictions placed on the data.
    - Data quality information – contains dataset quality information and lineage information.
    - Maintenance information – contains information about the scope and frequency of updating data.
    - Spatial representation information – contains information concerning the mechanisms used to represent spatial information in a dataset.
    - Reference system information – contains the description of the spatial and temporal reference system(s) used.
    - Content information – contains information identifying the feature catalog used and/or information describing the content of a coverage dataset.
    - Portrayal Catalog reference information – contains information identifying the portrayal catalog used, if any.
    - Distribution information – contains information about the distributor of, and options for obtaining a resource.

- Metadata extension information – contains information about user specified extensions, if any.
- Application schema information – contains information about the application schema used to build a dataset, if any.

ISO 19115-2 adds one package:

- Acquisition information – contains information on instruments, operations, platforms, objectives, requirements and acquisition plan

ISO 19115-2 extends the following ISO 19115 packages with structures specific to gridded data:

- Data quality information
- Spatial representation information
- Content information

GOES-R ISO Series Metadata uses applicable parts of all ISO 19115 and 19115-2 packages except Portrayal Catalog, Application Schema and Metadata Extensions.

6.0 OFF-THE-SHELF NETCDF APPLICATIONS AND UTILITIES

There are many off-the-shelf netCDF visualization and analysis applications, some of which interpret the CF metadata convention projections and other constructs. For example, Unidata's Integrated Data Viewer (IDV) and NASA's Panoply netCDF Viewer can plot CF-compliant on a variety of map backgrounds.

Unidata has a web page that is updated periodically containing a list of commercial and open-source software products that provide visualization and analysis capabilities. This web page is located at http://www.unidata.ucar.edu/software/netcdf/software.html.

There is also a set of generic netCDF utilities that provide the capability to dump (ncdump), copy (nccopy), generate (ncgen), and compare (nccmp). The first three are tools described in the NUG, and are developed by Unidata. These software tools are located at the Unidata web site. The compare tool software is located at http://nccmp.sourceforge.net.

7.0 SUMMARY PRODUCT AND DATA DESCRIPTIONS

7.1 Level 0 Products Overview

Level 0 products contain the observation data received from the instruments on-board the GOES-R series satellites. The data is in the form of CCSDS packets as generated by the instruments or spacecraft. The Level 0 products contain an array of CCSDS packets generated and downlinked. The CCSDS packets in the Level 0 products have not been modified by the ground system.

The Level 0 products contain spacecraft generated Orbit and Attitude/Angular Rate (OAR) data in a CCSDS packet for the science data's sensing period. This OAR data is needed to navigate the Level 0 data.

In addition, instrument science data, science and engineering telemetry, and diagnostic data, if available, are all inserted in the Level 0 products.

The Level 0 products contain metadata that can be used for cataloguing, such as formal product name, sensing period, resolution, data source related information, search keywords, and error information.

There are six types of GOES-R Level 0 product files corresponding to the following instruments or instrument suites:

- ABI
- GLM
- SUVI
- EXIS
- SEISS
- MAG

The EXIS Level 0 product includes CCSDS packets from both the XRS and EUVS. The SEISS Level 0 product includes CCSDS packets from each sensor in the space environment suite including the EHIS, MPS-HI, MPS-LO, and SGPS.

Level 0 product files use the netCDF-4 file format and contain data for a specific time interval. The time interval contained within a Level 0 product file varies for each type of Level 0 product based on the instrument's sensing timeline, science data dependencies and volume, and the relationship to the time interval covered in Level 1b product files.

The volume, paragraph, and page number where detailed information on each type of Level 0 product is defined in Table 7.1, PUG Location for Level 0 Products.

Table 7.1 PUG Location for Level 0 Products

Level 0 Product	PUG Volume, Paragraph, Page Number
ABI	Volume 2, Paragraph 2.2, page 13 ***update will be supplied in PUG version D***
GLM	Volume 2, Paragraph 2.4, page 29 ***update will be supplied in PUG version D***
SUVI	Volume 2, Paragraph 2.7, page 43 ***update will be supplied in PUG version D***
EXIS	Volume 2, Paragraph 2.3, page 24 ***update will be supplied in PUG version D***
SEISS	Volume 2, Paragraph 2.6, page 38 ***update will be supplied in PUG version D***
MAG	Volume 2, Paragraph 2.5, page 34 ***update will be supplied in PUG version D***

7.2 Level 1B Products Overview

The Level 1b products contain radiometrically calibrated, and, in the case of ABI, GLM, and SUVI data, geometrically corrected Level 0 observation data. The Level 0 observation data is processed so that its values are in standard units of physical quantities that simplify subsequent processing. The Level 1b products contain the navigation data and timing information that enable locating the Level 1b processed observation data in space and time.

In the case of the ABI Level 1b product, Radiances, the Level 0 instrument detector samples are resampled to the ABI fixed grid. The ABI fixed grid is a projection relative to the ideal location of a satellite in geostationary orbit. This is a change from the previous generation GOES Level 1 earth imagery (i.e. GVAR) enabling the product's image data to be geospatially normalized.

Instances of an ABI Level 1b product, Radiances, contain different areas of earth coverage. The standard coverage regions are defined in Table 7.2-1, Radiances Product Standard Coverage Regions.

Table 7.2-1 Radiances Product Standard Coverage Regions

Coverage Region	Description
Full Disk	Near hemispheric earth region centered at the longitude of the sensing satellite.
CONUS	An approximately 3000 km x 5000 km region intended to cover the continental United States within the constraints of viewing angle from the sensing satellite.
Mesoscale	An approximately 1000 km x 1000 km dynamically centered region in the instrument's field of regard. The particular coverage region associated with a mesoscale product is operator- selected to support high-rate temporal analysis of environmental conditions in regions of interest.

The GLM Level 1b product, which is composed of valid radiometrically, corrected and navigated high energy events is not distributed to user's standalone. Only the GLM Level 2+ product that contains the Level 1b high energy events and the derived lightning detection data is made available to users.

The Level 1b products contain product-level metadata that is useful in interpreting the processed observation data, and verifying its integrity and that of the sensing instrument. The Level 1b products also contain product-level metadata that can be used for cataloguing, such as formal product name, geographic coverage area in the case of the Radiances product, sensing period, resolution, data source related information, and search keywords, and error information.

The Level 1b products are made available in two forms using two different distribution mechanisms. netCDF-4 Level 1b product files are made available by the NOAA Product Distribution and Access (PDA) system. Note that a FITS formatted Solar Imagery: X-Ray product file is also available. In addition, a CCSDS space packet form of the Level 1b products is made available via GRB.

The volume, paragraph, and page number where detailed information on each type and form of Level 1b product is defined in Table 7.2-2, PUG Location for Level 1b Products.

Table 7.2-2 PUG Location for Level 1b Products

	PUG Volume, Paragraph, Page Number	
Level 1b Product	**netCDF / FITS**	**GRB**
Radiances	Volume 3, Paragraph 5.1.3, page 24	Volume 4, Paragraph 7.1.3, page 55
Lightning Detections (Level 2+; GLM Level 1b not available)		Volume 4, Paragraph 7.2, page 87 ***update will be supplied in PUG version C.4***
Solar Imagery: X-Ray	Volume 3, Paragraph 5.11, page 177 ***update will be supplied in PUG version C.3***	Volume 4, Paragraph 7.5, page 127 ***update will be supplied in PUG version C.3***
Solar Flux: X-Ray	Volume 3, Paragraph 5.5, page 95 ***update will be supplied in PUG version C.4***	Volume 4, Paragraph 7.3.3, page 113 ***update will be supplied in PUG version C.4***
Solar Flux: EUV	Volume 3, Paragraph 5.4, page 75 ***update will be supplied in PUG version C.4***	Volume 4, Paragraph 7.3.1, page 108 ***update will be supplied in PUG version C.4***
Energetic Heavy Ions	Volume 3, Paragraph 5.7, page 124 ***update will be supplied in PUG version C.3***	Volume 4, Paragraph 7.4.1, page 119 ***update will be supplied in PUG version C.3***

	PUG Volume, Paragraph, Page Number	
Level 1b Product	**netCDF / FITS**	**GRB**
Magnetospheric Electrons and Protons: Low Energy	Volume 3, Paragraph 5.8, page 143 ***update will be supplied in PUG version C.3***	Volume 4, Paragraph 7.4.3, page 122 ***update will be supplied in PUG version C.3***
Magnetospheric Electrons and Protons: Medium and High Energy	Volume 3, Paragraph 5.9, page 153 ***update will be supplied in PUG version C.3***	Volume 4, Paragraph 7.4.5, page 123 ***update will be supplied in PUG version C.3***
Solar and Galactic Protons	Volume 3, Paragraph 5.10, page 164 ***update will be supplied in PUG version C.3***	Volume 4, Paragraph 7.4.7, page 124 ***update will be supplied in PUG version C.3***
Geomagnetic Field	Volume 3, Paragraph 5.6, page 110 ***update will be supplied in PUG version C.4***	Volume 4, Paragraph 7.6, page 129 ***update will be supplied in PUG version C.4***

7.3 Level 2+ Products Overview

The Level 2+ products contain environmental physical quantities, such as Cloud Top Height, Land Surface (Skin) Temperature, and Hurricane Intensity. Except for the Lightning Detection product, the primary source data for generating the Level 2+ products is the 16 bands of ABI Level 1b Radiances product data. In addition to the ABI Level 1b data, National Weather Prediction (NWP) forecast model output data, which is received periodically by the GOES-R series ground system several times a day, is key ancillary source data for generating several of the Level 2+ products. Furthermore, there are a few other dynamic ancillary data sets used in the generation of Level 2+ product containing information, such as current snow and ice extents, and sea surface temperature in the western hemisphere.

There are several types of Level 2+ products. There are one or more Level 2+ products of each type. The types of Level 2+ products are as follows:

- Aerosols
- Clouds
- Precipitation
- Atmospheric Vertical Profiles
- Radiation
- Winds
- Land
- Ocean
- Lightning

All of the Level 2+ products other than the winds, hurricane intensity, and lightning products are gridded data sets. There are two projections associated with these gridded Level 2+ products: the ABI fixed grid and; global latitude/longitude grid. The ABI fixed grid is a projection relative to the ideal location of a satellite in geostationary orbit. The global latitude/longitude grid has data points at specific degrees of latitude and longitude, or fractions thereof. The radiation products are the only gridded Level 2+ products on the global latitude/longitude grid. The remaining gridded Level 2+ products are on the ABI fixed grid. The environmental quantity data for the winds, hurricane intensity, and lightning products is geo-located using latitude/longitude coordinates.

Instances of an ABI Level 2+ product contain different areas of earth coverage. The standard coverage regions are defined in Table 7.3-1, ABI Level 2+ Product Standard Coverage Regions.

Table 7.3-1 ABI Level 2+ Product Standard Coverage Regions

Coverage Region	Description
Full Disk	Near hemispheric earth region centered at the longitude of the sensing satellite.
CONUS	An approximately 3000 km x 5000 km region intended to cover the continental United States within the constraints of viewing angle from the sensing satellite.
Mesoscale	An approximately 1000 km x 1000 km dynamically centered region in the instrument's field of regard. The particular coverage region associated with a mesoscale product is operator- selected to support high-rate temporal analysis of environmental conditions in regions of interest.

The Level 2+ products contain product-level metadata that include statistical roll-ups of individual data points, and other data that is useful in interpreting the environmental physical quantity data, and verifying its integrity. The Level 2+ products also contain product-level metadata that can be used for cataloguing, such as formal product name, geographic coverage area, sensing period, resolution, data source related information, and search keywords, and error information.

The volume, paragraph, and page number where detailed information on each type of Level 2+ product is defined in Table 7.3-2, PUG Location for Level 2+ Products.

Table 7.3-2 PUG Location for Level 2+ Products

Level 2+ Product Type	Level 2+ Product	PUG Volume, Paragraph, Page Number
Aerosols	Aerosol Detection (including Smoke and Dust)	Volume 5A, Paragraph 5.2, page 76 ***update will be supplied in PUG version C.2***
	Aerosol Optical Depth	Volume 5A, Paragraph 5.3, page 88 ***update will be supplied in PUG version C.2***
	Volcanic Ash: Detection and Height	Volume 5B, Paragraph 2.2, page 38 ***update will be supplied in PUG version C.3***
Clouds	Cloud and Moisture Imagery	Volume 5A, Paragraph 5.1, page 23 TBS, TBS
	Clear Sky Masks	Volume 5A, Paragraph 5.7, page 234 ***update will be supplied in PUG version C.2***
	Cloud Optical Depth	Volume 5A, Paragraph 5.9, page 260 ***update will be supplied in PUG version C.2***
	Cloud Particle Size Distribution	Volume 5A, Paragraph 5.10, page 275 ***update will be supplied in PUG version C.2***
	Cloud Top Phase	Volume 5A, Paragraph 5.8, page 249 ***update will be supplied in PUG version C.2***
	Cloud Top Height	Volume 5A, Paragraph 5.4, page 200 ***update will be supplied in PUG version C.2***
	Cloud Top Pressure	Volume 5A, Paragraph 5.5, page 213 ***update will be supplied in PUG version C.2***
	Cloud Top Temperature	Volume 5A, Paragraph 5.6, page 224 ***update will be supplied in PUG version C.2***
	Hurricane Intensity	Volume 5B, Paragraph 2.12, page 214 ***update will be supplied in PUG version C.3***
Precipitation	Rainfall Rate/QPE	Volume 5B, Paragraph 2.4, page 72 ***update will be supplied in PUG version C.3***

Level 2+ Product Type	Level 2+ Product	PUG Volume, Paragraph, Page Number
Atmospheric Vertical Profiles	Legacy Vertical Moisture Profile	Volume 5A, Paragraph 5.11, page 290 ***update will be supplied in PUG version C.2***
	Legacy Vertical Temperature Profile	Volume 5A, Paragraph 5.12, page 305 ***update will be supplied in PUG version C.2***
	Derived Stability Indices (5 indices: CAPE, Lifted Index, K Index, Showalter Index, Total Totals)	Volume 5B, Paragraph 2.9, page 145 ***update will be supplied in PUG version C.2***
	Total Precipitable Water	Volume 5A, Paragraph 5.13, page 320 ***update will be supplied in PUG version C.2***
Radiation	Downward Shortwave Radiation: Surface	Volume 5B, Paragraph 2.7, page 112 ***update will be supplied in PUG version C.3***
	Reflected Shortwave Radiation: TOA	Volume 5B, Paragraph 2.8, page 128 ***update will be supplied in PUG version C.3***
Winds	Derived Motion Winds	Volume 5B, Paragraph 2.11, page 185 ***update will be supplied in PUG version C.3***
Land	Fire / Hot Spot Characterization	Volume 5B, Paragraph 2.5, page 285 ***update will be supplied in PUG version C.3***
	Land Surface (Skin) Temperature	Volume 5B, Paragraph 2.6, page 99 ***update will be supplied in PUG version C.3***
	Snow Cover	Volume 5B, Paragraph 2.3, page 62 ***update will be supplied in PUG version C.3***
Ocean	Sea Surface (Skin) Temperature	Volume 5B, Paragraph 2.10, page 167 ***update will be supplied in PUG version C.3***
Lightning	Lightning Detection: 1) Flashes 2) Groups 3) Events	Volume 5A, Paragraph 5.14, page 335 ***update will be supplied in PUG version C.4***

7.4 Instrument Calibration Data Overview

Instrument calibration data is a general term used for downlinked science and engineering and science telemetry, and sensor data obtained from instrument-specific calibration targets. Instrument calibration data is used to:

- Radiometrically calibrate and navigate observation data during Level 1b processing.
- Monitor and evaluate the health and performance of an instrument over its life-cycle.

Some calibration targets are integrated into an instrument, such as an internal calibrated black body, a solar reflective target or an intrinsic light source. Other calibration targets are external sources that are within the field of regard of an instrument, such as the Sun, Moon, stars or space.

The GOES-R imagers, ABI and SUVI, perform calibration tasks interleaved with operational observations as part of their nominal sensing cadence. In the case of the ABI, there are four types of calibration data: Internal Calibration Target (ICT) looks, space looks, Solar Calibration Target (SCT) looks, and lunar scans. ICT and Space Look are generated by the ABI. ICT data is used to compute detector gain coefficients for the ABI emissive channels. Space and SCT looks are used to compute detector gain coefficients for ABI reflective channels. Lunar scans are collected as part of an ABI mode 3 timeline, when the moon is in the field of regard of the instrument. The coverage area is equivalent to a mesoscale scene, and consists of two swaths.

The volume, paragraph, and page number where detailed information on each type and form of instrument calibration data is defined in Table 7.4, PUG Location for Level 1b Products.

Table 7.4 PUG Location for Instrument Calibration Data

Instrument	PUG Volume, Paragraph, Page Number
ABI	Volume 3, Paragraph 5.1.5, page 56
GLM	***will be supplied in PUG version C.4***
SUVI	***will be supplied in PUG version C.3***
EXIS	***will be supplied in PUG version C.4***
SEISS	***will be supplied in PUG version C.3***
MAG	***will be supplied in PUG version C.4***

7.5 Processing Parameters Overview

****** This paragraph will be supplied in PUG version D. ******

7.6 Algorithm Packages Overview

****** This paragraph will be supplied in PUG version D. ******

7.7 ISO Series Metadata Overview

GOES-R metadata is designed to serve two purposes:

- To support long-term archive and facilitate data discovery, evaluation, retrieval, use and reuse.
- To provide supplemental information for further processing, algorithm development, diagnostic and anomaly resolution and better understanding of each dataset.

For each Level 0, Level 1b, and Level 2+ product, ABI sample outlier data, instrument calibration data, and Level 1b and Level 2+ processing parameters and algorithm packages, metadata is provided in both an ISO-compliant XML product series (i.e. collection) level file. This metadata is in addition to the embedded native metadata existing in the GOES-R product and data files and is used to discover, display, exploit and further process the data. The ISO series metadata contains a set of "quasi-static" metadata elements that describe a collection of instances of a product or data. Their format, content, and citations to documents and points of contact are provided. Note that a complete ISO metadata record is produced by combining the series metadata with metadata in the product and data files using the ncISO functionality available at the NOAA Data Centers.

The detailed listings of ISO series metadata for GOES-R products and data are located in Appendix X, GOES-R ISO Series Metadata. This is a special standalone appendix to the PUG. This appendix includes a table of contents with a paragraph reference to each ISO series metadata file.

8.0 PRODUCT AND DATA FILENAME CONVENTIONS

The filenames for GOES-R product and data files follow a set of conventions to achieve standardization.

GOES-R product and data filenames are case-sensitive and no greater than 255 characters. Alphanumeric characters, underscores, hyphens, and periods are used, and blanks are not used. GOES-R filenames indicate the source, content, file type, and creation date and time of the product or data. In the case of observation data, the period of time when the observation occurred is included. In the case of time-sensitive status information, the start time of when it is valid is included. In the case of GOES-R data files that are configuration controlled internally by the GOES-R system, the version associated with the data file is included.

The syntax for capturing this information is structured. String fields are used to identify each of these characteristics. String fields are concatenated together in a prescribed order and delimited by underscores to create a filename string. A period is used to delimit the final string field, file extension, which indicates the file format.

Source

Two string fields are related to identifying the product or data file's source. They are as follows:

- System environment where the file is created. The system environment defines whether the file is created by the operational system or a test system. The system environment also defines whether the data in the file is real-time, test, playback, or simulated data. Real-time data created by the operational system support the mission. GOES-R configuration managed data files made available to users, including ISO series metadata, processing parameters, and algorithm packages, do not include the system environment string field in their filenames.
- Platform (i.e. satellite) identifier associated with the file. The data in the file is associated with only one of the GOES-R series satellites, either the source of the data in the file, or data that is applicable to only one of the satellites. Specific Level 0, 1b, and 2+ product files are associated with a single satellite. Processing parameters used by Level 1b software are associated with an instrument on a specific satellite.

Content

The Data Short Name (DSN) is a GOES-R standard term for a string field identifying the content of a GOES-R product or data file. DSN strings for GOES-R product and data files are often composed of multiple concatenated sub-fields. For example, in the case of ABI Level 1b product files, the DSN is a concatenation of:

- Instrument identifier, processing level, and type of product ("ABI-L1b-RAD")
- Type of image sensed ("F" for Full Disk, "C" for CONUS, and "M" for mesoscale)
- Mesoscale image number ("1" or "2")
- ABI mode of operation ("M3" for mode 3 and "M4" for mode 4)
- ABI channel ("Cxx" where xx = 01 – 16)

For example, the DSN for an ABI Level 1b Radiances full disk channel 7 product sensed in mode 3 is "ABI-L1b-RADF-M3C07".

File Extension

Every GOES-R product and data file has a file extension. The file extension defines the format of the file. It is the last string field in the filename, and delimited by a period. For example, the file extension for a netCDF-4 product file is "nc".

Creation Date and Time

The date and time the file is created. This string field is included in all GOES-R products and data filenames except GOES-R configuration managed data files made available to users, including ISO series metadata, processing parameters, and algorithm packages.

Observation Period Date and Time

The start and end date and time associated with the raw or processed observation data in the file. GOES-R configuration managed data files made available to users, including ISO series metadata, processing parameters, and algorithm packages, do not include this string field in their filenames.

Status Valid Date and Time

The start time of the data file that contains status information. This string field applies to the GRB Information file only.

Version

The version associated with the data file. This string field applies to ISO series metadata, processing parameters, and algorithm packages only.

Table 8.0, Product and Data Filename Applicable Fields summarize the filename string fields used for different types of GOES-R product and data files.

Table 8.0 Product and Data Filename Applicable Fields

	Source				Date and Time Fields			
	System Env	**Platform ID**	**Content (DSN)**	**File Extension**	**Creation**	**Observation Period Start & End**	**Status Valid Start**	**Version**
Level 0 Product	x	x	x	x	x	x		
Level 1b Product	x	x	x	x	x	x		
Level 2+ Product	x	x	x	x	x	x		
GRB Information	x	x	x	x	x		x	
ABI Sample Outlier Data	x	x	x	x	x	x		
Instrument Calibration Data	x	x	x	x	x	x		
ISO Series Metadata			x	x	x			x
Algorithm Package			x	x				x
Level 1b Processing Parameters		x	x	x				x
Level 2+ Processing Parameters			x	x				x

Appendix A in the Level 0, 1b, and 2+ PUG volumes provide the comprehensive filename specifications for the products and data files defined in the respective volume.

9.0 POINTS OF CONTACT AND PRIMARY RESPONSIBILITY

Table 9.0 lists the Points of Contact (POC) and NOAA Office of Primary Responsibility for each data item included in this PUG.

Table 9.0 POC and Primary Responsibility

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L0	ABI	Changyong Cao NESDIS/STAR Satellite Calibration and Data Assimilation Branch Changyong.cao@noaa.gov 301-683-2561
L2+	Aerosol Detection	Liqun Ma NESDIS/OSPO Satellite Products Branch liqun.ma@noaa.gov 301-763-8142 x 196
L2+	Aerosol Optical Depth	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Clear Sky Masks	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud & Moisture Imagery	Paul Haggerty NESDIS/OSPO Satellite Products Branch paul.haggerty@noaa.gov 301-817-3876
L2+	Cloud Optical Depth	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud Particle Size Distribution	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L2+	Cloud Top Height	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud Top Phase	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud Top Pressure	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud Top Temperature	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Cloud Type	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Derived Motion Winds	Hongming Qi NESDIS/OSPO Satellite Products Branch hongming.qi@noaa.gov 301-763-8142 x 114
L2+	Derived Stability Indices	Awdhesh Sharma NESDIS/OSPO Satellite Products Branch awdhesh.sharma@noaa.gov 301-763-8142 x 185
L2+	Downward Shortwave Radiation: Surface	Hanjun Ding NESDIS/OSPO Satellite Products Branch hanjun.ding@noaa.gov 301-763-8142 x 124

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L1b	Energetic Heavy Ion	Janet Green NGDC janet.green@noaa.gov 303-497-4845
L0	EXIS	William Denig NESDID/NGDC Solar Terrestrial Physics Division William.Denig@noaa.gov 303-497-6323
L2+	Fire/Hot Spot Characterization	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160
L2+	Snow Cover	Sean Helfrich NESDIS/OSPO NOAA Ice Center sean.helfrich@noaa.gov 301-817-3934
L1b	Geomagnetic Field	Robert Redmon NOAA/NGDC Solar Terrestrial Physics Division Robert.Redmon@noaa.gov 303-497-4331
L0	GLM	Changyong Cao NESDIS/STAR Satellite Calibration and Data Assimilation Branch Changyong.cao@noaa.gov 301-683-2561
L1b/L2+	GOES Rebroadcast Content	Marlin Perkins Satellite Services Division Direct Services Branch marlin.o.perkins@noaa.gov 301-817-4523
L2+	Hurricane Intensity	Liqun Ma NESDIS/OSPO Satellite Products Branch liqun.ma@noaa.gov 301-763-8142 x 196

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L2+	Land Surface (Skin) Temperature	Hanjun Ding NESDIS/OSPO Satellite Products Branch hanjun.ding@noaa.gov 301-763-8142 x 124
L2+	Legacy Vertical Moisture Profile	Awdhesh Sharma NESDIS/OSPO Satellite Products Branch awdhesh.sharma@noaa.gov 301-763-8142 x 185
L2+	Legacy Vertical Temperature Profile	Awdhesh Sharma NESDIS/OSPO Satellite Products Branch awdhesh.sharma@noaa.gov 301-763-8142 x 185
L2+	Lightning Detection (Events, Groups, Flashes)	Paul Haggerty NESDIS/OSPO Satellite Products Branch paul.haggerty@noaa.gov 301-817-3876
L0	Magnetometer	William Denig NESDIS/NGDC Solar Terrestrial Physics Division William.Denig@noaa.gov 303-497-6323
L1b	Magnetospheric Electrons and Protons: Medium and High Energy	Janet Green NGDC janet.green@noaa.gov 303-497-4845
L1b	Magnetospheric Electrons and Protons: Low Energy	Janet Green NGDC janet.green@noaa.gov 303-497-4845

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L1b	Radiances	Bonnie Morgan NESDIS/OSPO bonnie.morgan@noaa.gov 301-817-3871 Paul Haggerty NESDIS/OSPO Satellite Products Branch paul.haggerty@noaa.gov 301-817-3876
L2+	Rainfall Rate (RR) / Quantitative Precipitation Estimation (QPE)	Limin Zhao NESDIS/OSPO Satellite Products Branch limin.zhao@noaa.gov 301-763-8142 x 125
L2+	Reflected Shortwave Radiation: Top of Atmosphere (TOA)	Hanjun Ding NESDIS/OSPO Satellite Products Branch hanjun.ding@noaa.gov 301-763-8142 x 124
L2+	Sea Surface (Skin) Temperature	John Sapper NESDIS/OSPO Satellite Products Branch john.sapper@noaa.gov 301-763-8142 x 103
L0	SEISS	William Denig NESDIS/NGDC Solar Terrestrial Physics Division William.Denig@noaa.gov 303-497-6323
L1b	Solar and Galactic Protons	Janet Green NGDC janet.green@noaa.gov 303-497-4845
L1b	Solar Flux: Extreme Ultra-Violet Irradiances (EUV)	Rodney Viereck NOAA/NWS Space Weather Prediction Center Rodney.Viereck@noaa.gov 303-497-7348

Processing Level	Product	POC and NOAA Office of Primary Responsibility
L1b	Solar Flux: X-Ray	Rodney Viereck NOAA/NWS Space Weather Prediction Center Rodney.Viereck@noaa.gov 303-497-7348
L1b	Solar Imagery: X-Ray	Steven Hill NOAA/NWS Space Weather Prediction Center Steven.Hill@noaa.gov 303-497-3283
L0	SUVI	William Denig NESDID/NGDC Solar Terrestrial Physics Division William.Denig@noaa.gov 303-497-6323
L2+	Total Precipitable Water (TPW)	Limin Zhao NESDIS/OSPO Satellite Products Branch limin.zhao@noaa.gov 301-763-8142 x 125
L2+	Volcanic Ash	Gilberto Vicente NESDIS/OSPO Satellite Products Branch gilberto.vicente@noaa.gov 301-763-8142 x 160

APPENDIX A ACRONYM AND GLOSSARY LIST

The following acronyms are used throughout the volumes of this document.

Acronym	Description(s)
ABI	Advanced Baseline Imager
ADRS	Ancillary Data Relay System
ADT	Advanced Dvorak Technique
ACDD	Attribute Convention for Data Discovery
ACH	ABI Cloud Height
ACM	ABI Cloud Mask
ACT	ABI Cloud Top Type and Phase
ADP	Aerosol Detect Product
ANSI	American National Standards Institute
AOD	Aerosol Optical Depth
AOS	Advanced Orbiting Systems
API	Application Programming Interface
APID	Application Process Identifier
ASCII	American Standard Code for Information Interchange
ATCF	Automated Tropical Cyclone Format
AU	Astronomical Unit
AVHRR	Advanced Very High Resolution Radiometer
AWG	Algorithm Working Group
AWIPS	Advanced Weather Interactive Processing System
BCH	Bose Chaudhuri Hocquenghem
BPSK	Binary Phase Shift Keying
BRF	Body Reference Frame
BT	Brightness Temperature
BTD	Brightness Temperature Difference
C-N-O	Carbon-Nitrogen-Oxygen
CAL	Calibration
CAPE	Convective Available Potential Energy
CCD	Charge-Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CCW	Counterclockwise
CDA	Command and Data Acquisition
CDO	Central Dense Overcast
CDRL	Contract Data Requirements List

Acronym	Description(s)
CF	Climate and Forecast
Ch	Channel
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CLASS	Comprehensive Large Array-data Stewardship System
CMI	Cloud and Moisture Imagery
CMIP	Cloud and Moisture Imagery Product
COD	Cloud Optical Depth
CONUS	Continental United States
CPS	Cloud Particle Size
CRC	Cyclic Redundancy Checksum
CSR	Clear Sky Radiance
CRTM	Community Radiative Transfer Model
CST	Clear Sky Transmission
DC	Direct Current
DCOMP	Daytime Cloud Optical and Microphysical Properties
DEM	Digital Elevation Model
DID	Data Item Description
DLR	Downward Longwave Radiation: Surface
DMSP	Defense Meteorological Satellite Program
DN	Digital Number (number of counts)
DQF	Data Quality Flag
DSN	Data Short Name
DSR	Downward Shortwave Radiation
DVB-S2	Digital Video Broadcast – Second Generation
8PSK	8 level Phase Shift Keying
ECI	Earth-Centered Inertial
EHIS	Energetic Heavy Ion Sensor
EIR	Enhanced Infrared
EM	Enterprise Management
EMWIN	Emergency Managers Weather Information Network
EOS	Earth Observing System
ESPC	Environmental Satellite Processing Center
EU	Electronics Unit
EUV	Extreme Ultraviolet
EUVS	Extreme Ultraviolet Spectrometer
EXIS	Extreme Ultraviolet and X-ray Irradiance Sensor

Acronym	Description(s)
F&PS	Functional & Performance Specification
FDC	Fire Characterization
Fe	Iron
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FITS	Flexible Image Transport System
FNC	Filename Convention
FTE	Fine Track Error
FOR	Field of Regard
FOV	Field of View
GCMD	Global Change Master Directory
GFP	Government Furnished Property
GFS	Global Forecast System
GLM	Geostationary Lightning Mapper
GSFC	Goddard Space Flight Center (NASA)
GOES	Geostationary Operational Environmental Satellite
GPA	Ground Processing Algorithm
GPG	GOES-R Product Generation
GRB	GOES-R series Rebroadcast
GRS 80	Geodetic Reference System 1980
GS	Ground Segment
GTOP	Global Topographic
GVAR	GOES Variable Format
H	Hydrogen
HDF	Hierarchical Data Format
HDLC	High-Level Data Link Control
HDU	Header and Data Units
He	Helium
HRIT	High Rate Information Transmission
Hz	Hertz
ICAO	International Civil Aviation Organization
ICT	Internal Calibration Target
ID	Identification
IDV	Integrated Data Viewer
IF	Intermediate Frequency
IFC	In-Flight Calibration

Acronym	Description(s)
IMS	Interactive Multisensor Snow and Ice Mapping System
INFO	Information
ISM	ISO Series Metadata
IO	Input/Output
IR	Infrared
ISO	International Organization for Standardization
ITT	International Telephone and Telegraph Industries
KI	K-Index
KPP	Key Performance Parameter
L0	Level 0
L1b	Level 1b
L2+	Level 2+
LAP	Legacy Atmospheric Profile
LCFA	Lightning Cluster-Filter Algorithm
LET	Linear Energy Transfer
LDPC	Low Density Parity Check
LHCP	Left Hand Circular Polarization
LI	Lifted Index
LNA	Low Noise Amplifier
LOS	Line of Sight
LR	Lower Right
LRC	Local Radiative Center
LSB	Least Significant Bit
LSE	Low Surface Emissivity
LST	Land Surface (Skin) Temperature
LUT	Look-up Table
LVM	Legacy Vertical Moisture
LVT	Legacy Vertical Temperature
LWIR	Long Wave Infrared
MAG	Magnetometer
Mg	Magnesium
MM	Mission Management
MODIS	Moderate Resolution Imaging Spectrometer
MP	Mixed Phase
MPS-HI	Magnetospheric Particle Sensor - High Energy
MPS-LO	Magnetospheric Particle Sensor - Low Energy

Acronym	Description(s)
MSB	Most Significant Bit
MSG	Meteosat Second Generation
MSLP	Mean Sea Level Pressure
MUV	Mid Ultraviolet
MW	Microwave
MWIR	Medium Wave Infrared
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center (part of NESDIS)
NCEP	National Center for Environmental Predictions (part of NWS)
NCOMP	Nighttime Cloud Optical and Microphysical Properties
NcML	netCDF Markup Language
NedN	Noise Equivalent Change in Radiance
NedT	Noise Equivalent Differential Temperature
Ne-S	Neon-Sulfur
NESDIS	National Environmental Satellite, Data and Information Service
netCDF	Network Common Data Format
NGDC	National Geophysical Data Center
NHC	National Hurricane Center
NIRREF	Near Infrared Reflectance
NOAA	National Oceanic and Atmospheric Administration
NSOF	NOAA Satellite Operations Facility
NUG	nnetCDF User's Guide
NWP	Numerical Weather Prediction
NWS	National Weather Service
O&A	Orbit and Attitude
OAR	Orbit and Attitude/Angular Rate
OSPO	Office of Satellite and Product Operations
PD	Product Distribution
PDA	Product Distribution and Access
PFMFT	Positive Four Minus Five Test
PG	Product Generation
PLT	Post Launch Test
PMW	Passive Microwave
POC	Point(s) of Contact
POR	Probability of Rainfall
PORD	Performance and Operational Requirements Documents

Acronym	Description(s)
POST	Power On Self Test
PRT	Platinum Resistance Thermometer
PTR	Program Tracking Report
PUG	Product Users' Guide
QA	Quality Assurance
QC	Quality Control
QCF	Quality Control Flags
QPE	Quantitative Precipitation Estimation
QPSK	Quadrature Phase Shift Keying
RAD	Radiances
RBU	Remote Backup Facility
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RMSE	Root Mean Squared Error
RRQPE	Rainfall Rate Quantitative Precipitation Estimation
RT	Real-time Radiative Transfer
SARSAT	Search-and-Rescue Satellite Aided Tracking
SC	Spacecraft
SCT	Solar Calibration Target
SEISS	Space Environment In-Situ Suite
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SGML	Standard Generalized Markup Language
SGPS	Solar and Galactic Proton Sensor
Si	Silicon
SI	Showalter Index
SLW	Supercooled Liquid Water
SOCC	Satellite Operations Control Center
SOF	Sample Outlier File
SPS	Sun Positioning Sensor
SSCA	SEISS SGPS L1b Calibration Algorithm
SSEC	Space Science and Engineering Center (University of Wisconsin)
SSMI	Special Sensor Microwave Imager
SSMIS	Special Sensor Microwave Imager/Sounder
SST	Sea Surface Temperature
STAR	Center for Satellite Applications and Research

Acronym	Description(s)
SU	Sensor Unit
SUVI	Solar Ultraviolet Imager
SZA	Solar Zenith Angle
TBD	To Be Determined
TBR	To Be Resolved/Reviewed
TBS	To Be Supplied
TBX	The aggregation of TBD, TBR, and TBS
TC	Tropical Cyclone
TCFC	Tropical Cyclone Forecast Center
THREDDS	Thematic Real-time Environmental Distributed Data Services
TOA	Top-Of-Atmosphere
TPW	Total Precipitable Water
TT	Total Totals Index
UUID	Universally Unique Identifier
UL	Upper Left
USGS	United States Geological Survey
UTC	Coordinated Universal Time
VAA	Volcanic Ash
VLEN	Variable Length
VNIR	Visible Near Infrared
WCDAS	Wallops Command and Data Acquisition Station
WFO	Weather Forecast Offices
WMO	World Meteorological Organization
WVMD	Water Vapor Multilayered Detection
XML	Extensible Markup Language
XRS	X-Ray Sensor